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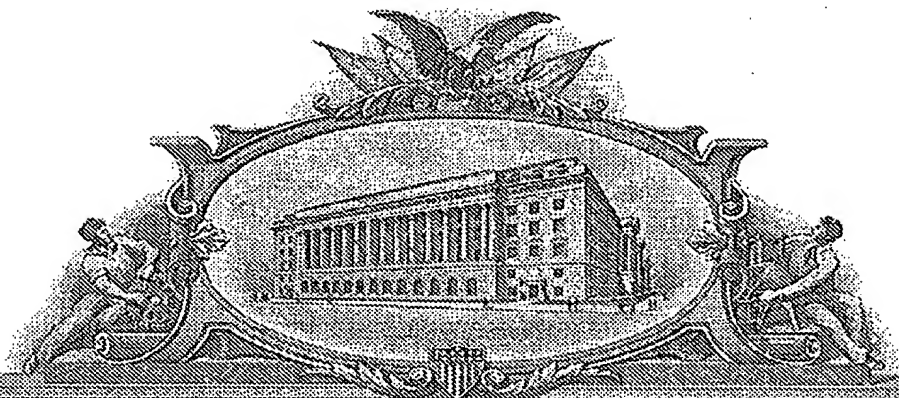
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<input type="checkbox"/> Additional inventors are being named on the _____ separately numbered sheets attached hereto						
TITLE OF THE INVENTION (500 characters max)						
RECONFIGURABLE FREQUENCY SELECTIVE SURFACES FOR REMOTE SENSING OF CHEMICAL AND BIOLOGICAL AGENTS						
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<input type="checkbox"/> Customer Number				Place Customer Number Bar Code Label here		
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.						
<input type="checkbox"/> No						
<input checked="" type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: National Science Foundation, DMR 0213623						

Respectfully submitted,

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January 14, 2004

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2003-2855

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Practitioner's Docket No.: 2003-2855 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: **D. Werner, et al.**

Serial No.:

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Filed: **January 14, 2004**

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For: **RECONFIGURABLE FREQUENCY SELECTIVE SURFACES FOR REMOTE SENSING OF CHEMICAL AND BIOLOGICAL AGENTS**

**Commissioner for Patents
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RECONFIGURABLE FREQUENCY SELECTIVE SURFACES FOR REMOTE SENSING OF CHEMICAL AND BIOLOGICAL AGENTS

GOVERNMENT SPONSORSHIP

This work was supported by the National Science Foundation under Grant No. DMR 0213623. Accordingly, the US Government may have certain rights in this invention.

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FIELD OF THE INVENTION

The present invention relates to reconfigurable frequency selective surfaces, and more particularly to a class of reconfigurable frequency selective surfaces that can be used for remote sensing of chemical and biological agents. The present invention also relates to reconfigurable switch elements that can be turned "ON" and "OFF" in response to remote stimuli, such as chemical and biological agents.

10

BACKGROUND OF THE INVENTION

Conventional Frequency Selective Surfaces ("FSS") consist of a metallic unit cell that is periodically replicated and printed on top of a thin dielectric substrate material. There has been a considerable amount of interest in FSS technology in recent years as they have been investigated for a variety of applications. These include electromagnetic filtering devices for reflector antenna systems, radomes, absorbers, and artificial electromagnetic bandgap materials. The majority of FSS designs have been considered for microwave and millimeter wave applications, however the concept is completely scalable to higher frequency ranges such as infrared and even optical frequencies.

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In most FSS applications the geometry and material parameters are designed to produce a static frequency response. However, several groups have investigated the possibility of tuning or reconfiguring an FSS so that its frequency response can be shifted or altered altogether while in operation. This can be accomplished either by changing the electromagnetic properties of the FSS screen or substrate, by altering the geometry of the structure, or by introducing elements into the FSS screen that vary the current flow between metallic patches.

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In the first class of Reconfigurable Frequency Selective Surfaces ("RFSS") the frequency response of the FSS is changed by altering the electromagnetic properties of the substrate. Several groups have realized this by utilizing a ferrite as the substrate material [3-8]. When a DC bias is applied across the ferrite substrate, the electrical properties are altered, making the electromagnetic waves appear electrically longer or shorter. By changing the DC bias the FSS can be tuned to higher or lower frequencies. However, there are some serious disadvantages associated with the concept of using ferromagnetic substrates. Ferrites have high mass, and large currents are required to maintain the DC bias across the substrate. Furthermore, setting up a DC bias over a large area of substrate is a complicated task. Nevertheless, a two-layer FSS with one or two ferrite substrates can be designed to switch between an absorber and a reflector at resonance by applying a DC bias to the substrate.

A related technique uses a liquid dielectric as the substrate. In this approach, a substrate cavity below the metallic screen is filled with a liquid dielectric or emptied to vary the permittivity. Varying the permittivity also varies the electrical wavelength inside the substrate, changing the frequency response. This technique has been demonstrated to tune the FSS frequency response, but it requires a complex design to properly handle the liquid substrate.

Another technique that alters the substrate properties uses a slotted FSS screen with a silicon substrate to produce a pass band at resonance under normal operation. However, when the silicon substrate is illuminated by an optical source with sufficient intensity, the silicon behaves like a conductor, making the pass band disappear. One final technique of interest involves using plasma to form a virtual FSS screen. Elements with a high plasma density behave like a metallic conductor. The plasma features can be altered thereby changing the frequency response of the virtual FSS.

The second category of RFSS design techniques are those in which the geometry of the metallic screen elements is altered in such a way as to effect a desired change in the frequency response. One technique that has been reported involves using two FSS screens with identical apertures or patch elements and a dielectric or spacing layer in between. The front and back screens are shifted vertically or horizontally with respect to each other, which produces a corresponding change in the frequency spectrum. The bandwidth and resonance positions both change when the screens are displaced.

A second reconfiguration technique has been introduced that is based on microelectromechanical systems ("MEMS") technology. The metallic elements of the FSS are designed to be able to lay flat on the substrate or tilt up to 90° from the substrate. Thus, the incident radiation sees a variable-size element depending on the tilt angle of the metallic patches. This method for tuning the response of an FSS has been successfully demonstrated by Gianvittorio et al. (*IEE Electronics Letters*, Vol. 38, No. 25, Dec. 2002). However, it requires complex fabrication techniques and the ability to produce an external electromagnetic field in order to mechanically control the element positions.

The final class of RFSS to be considered incorporates circuit elements into the metallic screen that can be used to vary the current between patch elements. A technique has been proposed for controlling the response of an FSS by interconnecting metallic patches in its screen with lumped variable reactive elements (C. Mias, *IEE Electronics Letters*, Vol. 39, No. 9, May 2003). Although variable reactive elements were not used in experiment, the effect of varying reactive loads between patches was shown through numerical simulations to shift the position of stop bands. This technique was taken a step further by including varactor diodes to tune the stop band of an FSS absorber.

Another option that has been investigated is to use PIN diodes as switches between metallic patch elements. PIN diodes either allow or inhibit current flow between patch elements depending on the voltage bias applied across the diode. Thus, they can be used to make a resonance disappear, or they can drastically change a resonance location based on the RFSS design. The active FSS described by Chang, et al. also incorporates a ferrite substrate so that the resonant frequency may be tuned by biasing the ferrite substrate or by switching the PIN diodes to go from a transmitting to a reflecting mode and back again (*IEEE Proc. Microwaves, Antennas and Propagation*, Vol. 143, No. 1, Feb. 1996). One difficulty with using PIN diodes as switches in RFSS is the added complexity of incorporating bias lines into the design.

Several interesting applications have been suggested for RFSS that switch on or off using diodes. The design procedure for a horn antenna that has two tapered walls was described by Philips, et al. (*IEE Electronics Letters*, Vol. 31, No. 1, Jan. 1995). The outer wall of the antenna is made of a solid metallic sheet while the second, narrower wall consists of a RFSS that incorporates diodes so that it can be switched from transmitting to reflecting.

In the transmitting state, the horn antenna has a relatively wide aperture, but when the RFSS is switched to a reflecting state it acts as the inner wall of the horn antenna giving it a narrower aperture. The same type of active RFSS was proposed for building walls in order to control the transparency of the structure at a given radio frequency.

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SUMMARY OF THE INVENTION

The present invention describes a new passive Reconfigurable Frequency Selective Surface comprising a periodic array of arbitrarily shaped, metallic patches interconnected by a matrix of switches. The invention advantageously enables each switch or switch type to be
10 independently addressed by applying remote stimuli such as light or analyte (chemical and/or biological). The unit cell formed by the grid of patches and switches can be optimized (e.g., via a Genetic Algorithm) for a desired frequency response by simply adjusting the ON/OFF state of each switch in the grid. Once the optimal switch settings have been determined, they can be conveniently stored in a look-up table for later use. This method is superior to
15 previous RFSS design concepts because it truly exploits the flexibility afforded by incorporating switches into FSS screens. It is demonstrated by this invention, through the examples provided herein, that a very simple set of patch elements interconnected with switches can be tailored to meet a wide variety of frequency response requirements.

DETAILED DESCRIPTION OF THE INVENTION

The present invention describes a new passive Reconfigurable Frequency Selective Surface comprising a periodic array of arbitrarily shaped metallic elements interconnected by a matrix of switches, where each switch or switch type can be independently addressed by applying external stimuli (light, chemical or biological analyte, etc.). This allows the
25 geometry of the passive FSS screen to be altered by reconfiguring the matrix of switches (i.e., "ON" and "OFF") such that different switch settings result in a unique reflection or transmission response. The RFSS can be designed to produce changes in the frequency and/or polarization response of the reflected or transmitted spectra of the surface in response to the external stimuli. Thus, the reconfiguration results in a change in the electromagnetic
30 properties or signature of the FSS, which can be interrogated and detected remotely using sources and detectors that are sensitive in the frequency range of interest. Such RFSSs have

application in diverse fields such as reconfigurable electromagnetic shielding and remote chemical and biological sensing.

Conventional Frequency Selective Surfaces consist of a metallic unit cell that is periodically replicated and printed on top of a thin dielectric substrate material. The geometry of the unit cell can be designed to transmit or reflect certain frequency bands. The present invention achieves a reconfigurable FSS by specifying a fixed metallic pattern and then introducing switches connecting the fixed metallic segments which may be turned "ON" or "OFF" to achieve a desired frequency response. Figure 1 is an example of a reconfigurable FSS geometry where switch elements connect a subset of fixed metallic dipoles elements. The resulting transmission and reflection spectra for the cases when all of the switches are either "ON" and "OFF" is given in Figure 2 a-b.

It is evident from these spectra that the frequency at which the single transmission and reflection passband is observed can be changed by turning on the switches, and hence changing the effective dimensions of the overall dipole element (i.e., fixed metal plus switch). The absolute passband frequencies and the difference in "ON" and "OFF" passband frequency can be easily tailored by adjusting the relative dimensions of the fixed metal dipole and connecting switch elements. For instance, the FSS can be configured for a frequency response to a linearly polarized incident plane wave. In addition, the FSS designs of the present invention can be scaled to produce surfaces with a response at frequencies in the microwave, infrared, and visible due to the inherent scalability of the electromagnetic theory used in their design.

In another embodiment of the invention, the FSS incorporates a multitude of different switches that can be turned ON and OFF either individually or in groups. Figures 3 – 5 depict a FSS pattern that is optimized using a genetic algorithm approach to provide 2 stop bands at 3.5 and 6 THz when the switches shown in blue in Figure 4 are turned "ON". Several different types of approaches can be used to optimize the present RFSS designs, including but not limited to those based on evolutionary programming, genetic algorithms and particle swarm optimization. Figures 6 – 7 show an example in which the FSS has been optimized to provide 3 stop bands at 4, 7 and 9 THz when the switches shown in blue in Figure 6 are turned "ON".

These designs may be fabricated using the same surface if each of the switches' locations can be addressed individually. However, many applications rely on external stimuli to provide the excitation required to turn the switches "ON" or "OFF". This includes chemical and biological sensing applications, where the switch elements are fabricated from materials that change their conductivity state in the presence of a particular chemical or biological analyte. In such case, groups of switches typically respond in unison to a particular chemical or biological analyte. Accordingly, where there are shared switches in the FSSs, they should be implemented using two different starting surfaces.

In a further embodiment of the invention, multiple types of switch elements are incorporated into a single FSS. In this embodiment, each of the different types of switch elements may be designed to respond differently to different chemical analyte mixtures to produce an FSS with unique passband characteristics that depend on the switch element settings. An example of such a surface along with its response is shown in Figures 8 and 9. For example, there are two sets of switches, blue and green, which can be independently turned "OFF," or "ON." When both the blue and green switches are "OFF," the FSS comprised of dipoles produces a single stop band at 22.3 THz, when the blue switches are "ON," the size of the dipoles doubles so that the FSS produces a single stop band at 11.3 THz, when the green switches are "ON," the short and long dipoles alternate so that the FSS produces dual stop bands at 9.5 and 18.3 THz, and when both the blue and green switches are "ON," the longer dipoles alternate with infinite metal strips so that the FSS acts as a high pass filter with a stop band at 11.3 THz. In this way, each state (i.e., switch setting) of the FSS produces a unique microwave, infrared, or optical signature. As described previously, a genetic algorithm or other optimization approach can be used to determine the optimal pattern of switch settings required in order to achieve a set of desired frequency responses (i.e., signatures).

The genetic algorithm is capable of optimizing the reconfigurable dipole pattern for a variety of target frequency responses. These optimized configurations can be placed in a database to be retrieved when reconfiguring the FSS to a desired frequency response. Although it may require some time to optimize the pattern for a set of target frequency responses, the optimizations only need to be performed once. Specific configurations can

then be quickly retrieved from a database and implemented to reconfigure the FSS in real time or analyze the resulting FSS signature.

Another embodiment of the invention, shown in **Figure 10**, comprises a cell geometry that can be used to produce a reconfigurable frequency response for both TE and TM polarizations. By using a genetic algorithm technique on this structure, the frequency responses for TE and TM polarizations can be individually optimized. This cell geometry contains both a fixed cross-dipole pattern and a set of switches, which can be individually turned on (connected) or off (disconnected). The goal is to specify one target frequency response for the TE polarization and another target frequency response for the TM polarization and allow the GA to find a set of switch values that achieves the target response. This embodiment of the invention, illustrated in **Figure 11**, indicates the switch configurations that are required to produce the responses shown in **Figure 12**. This particular design contains a reconfigurable cell geometry that is capable of producing either the same or a completely different frequency response for vertical and horizontal polarizations.

The cell geometry shown in **Figure 10** comprises a periodic metallic crossed-dipole pattern interconnected by a set of switches, which may be individually activated (turned on) or deactivated (turned off). The goal in this case is to identify the optimal switch settings that would lead to a desired target frequency response for horizontal polarization and another target frequency response for vertical polarization. **Figure 11** shows a reconfigurable FSS pattern that has been optimized (in this case using a genetic algorithm technique) to produce two stop-bands, one at 8 THz for a TE (Transverse Electric) polarized wave and the other at 4 THz for a TM (Transverse Magnetic) polarized wave. The genetic algorithm is used to determine which switches should be turned on and which ones should be turned off in order to produce the desired TE and TM responses. The transmission and reflection spectrums corresponding to this design are shown in **Figure 12**. These examples demonstrate the flexibility of the reconfigurable FSS design methodology, wherein the crossed-dipole pattern can be optimized for a variety of target frequency responses and the corresponding switch settings can be stored in a look-up table for future reference.

There are many uses for this technology, including but not limited to, its application to the development of new remote sensing systems for chemical and/or biological agents. In

these systems, the type of switches used in the RFSS are specifically designed to turn "ON" or "OFF" upon exposure to a variety of chemical and/or biological agents. Deployed sensors of this type can be interrogated remotely via directed radio frequency, infrared, and visible electromagnetic energy, allowing the frequency response of the reflected or transmitted signals to be correlated with a known set of environmental responses.

The FSS switches can be fabricated using materials that change conductivity state in the presence of certain chemical or biological analytes. Examples of such materials include chemically or biologically sensitive conductive polymers. The most common conductive polymers include derivatives of polythiophenes, polypyrrole and polyaniline, which have been shown to change their conductivity state by many orders of magnitude in the presence of chemical analytes. These conductive polymers have been shown to have sufficiently high conductivity in the frequency range of interest for these sensor applications (microwave and infrared) to serve as effective switch elements for the FSS. The conductivity of such materials has been enhanced by building percolation threshold composites that include carbon black, nanowires and carbon nanotubes. These conductive polymer materials are often extremely sensitive but not selective to particular analytes (i.e., conductivity changes are observed for more than one chemical). Moreover, the change in conductivity is proportional to the concentration of chemical that is present. Other molecular systems are also being developed with excellent selectivity to particular chemical and biological species. The materials used to fabricate the switches of the instant invention are not limited to conductive polymers and their derivatives, but instead include any class of materials that is capable of changing its conductivity state in the presence of chemical or biological analytes.

Incorporating chemically or biologically sensitive switches in predefined patterns on the RFSS allows it to automatically reconfigure to produce a unique optical signature in the presence of different chemical analyte mixtures. The entire sensor system is completed by remotely illuminating the FSS with a source of radiation of the desired frequency range and identifying the presence of certain chemicals based on the reflection or transmission spectra that are generated. For instance, a military application of the sensor system involves applying the RFSS on an unmanned aerial vehicle or as part of an unattended ground sensor, which can be remotely interrogated to detect the presence of chemical agents. This has advantages over other sensing approaches because the entire sensor is passive and does not

require an on-board source of energy. Moreover, such surfaces can be fabricated on flexible substrate materials such that they can be easily mounted onto a variety of platforms. Militarily significant examples include tanks and next generation soldier suits.

5 While the above-mentioned embodiments modeled the switches as ideal (i.e., either "ON" or "OFF"), the present invention also incorporates a more realistic response where the chemically or biologically sensitive switches are not completely selective to different chemicals and have a range of conductivity states between "ON" and "OFF". In such case, the signature of the RFSS is more complicated to interpret. However, this problem is similar to those being addressed by other sensor platforms, including on-chip conductivity based
10 sensors. In these sensors, the sensor chip is often trained under a variety of exposure conditions prior to use. The response that is collected during operation is then evaluated using pattern recognition algorithms (e.g., neural networks etc.) to determine the chemical analyte mixture present. This approach can also be extended to RFSS patterns beyond those described herein. Genetic algorithms can be used to design fractal surfaces that produce a
15 desired frequency response that is frequency and/or polarization sensitive. Such patterns are particularly useful in many practical samples when it is necessary to accommodate properties such as lossy switches, metals, and substrates and surfaces with finite substrate thickness.

20 While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various alterations in form and detail may be made therein without departing from the spirit and scope of the invention.

FIGURES

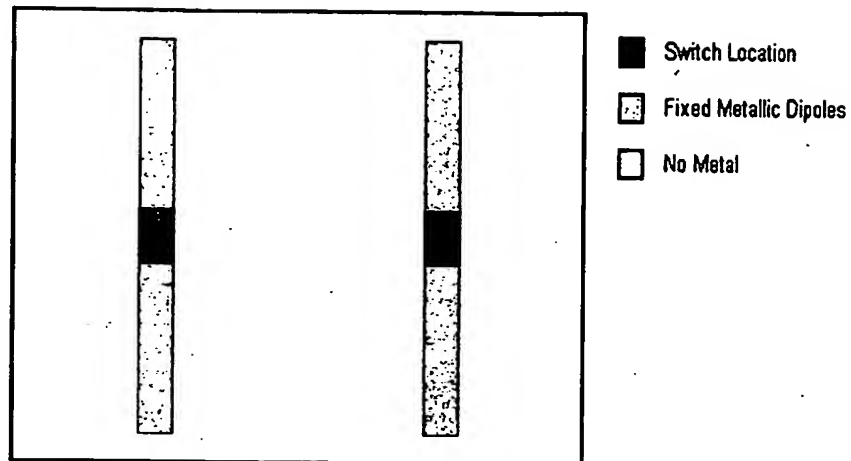


Figure 1. Reconfigurable FSS Geometry with 2 Configurations.

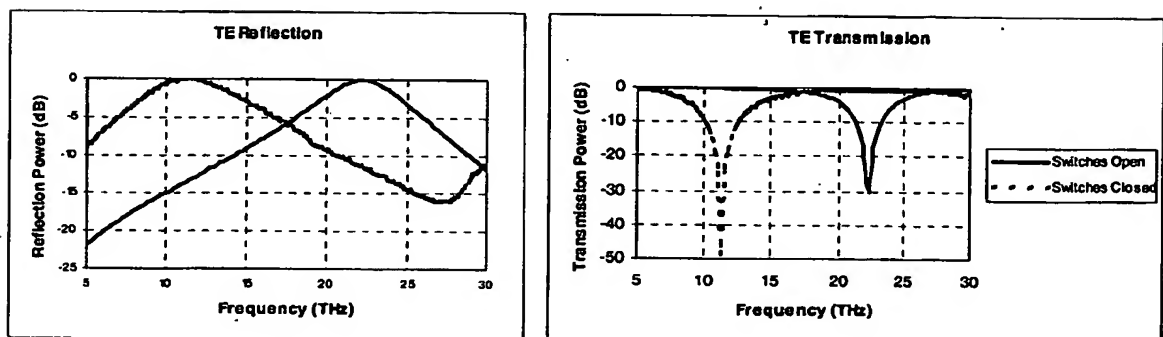


Figure 2. Transmission and Reflection Spectrums for Geometry in Figure 1.

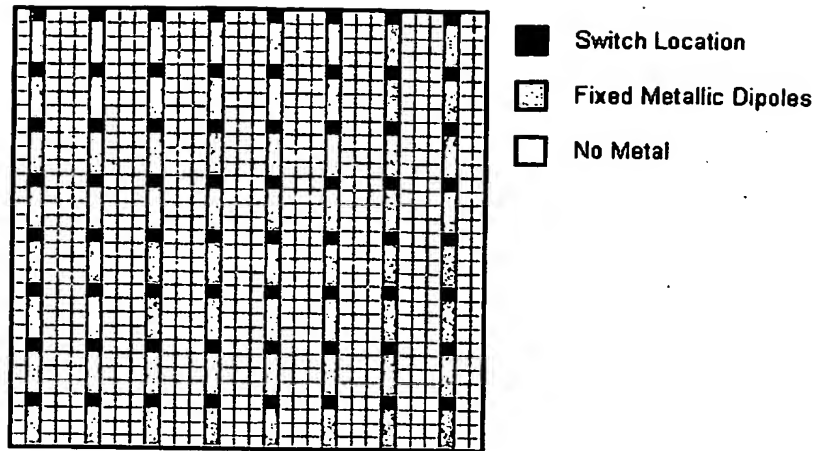


Figure 3. Reconfigurable FSS Geometry for Linear Polarization. Possible Switch Locations are Shown in Blue. Each Pixel is 1x1 Microns and the Unit Cell is 32x32 Microns.

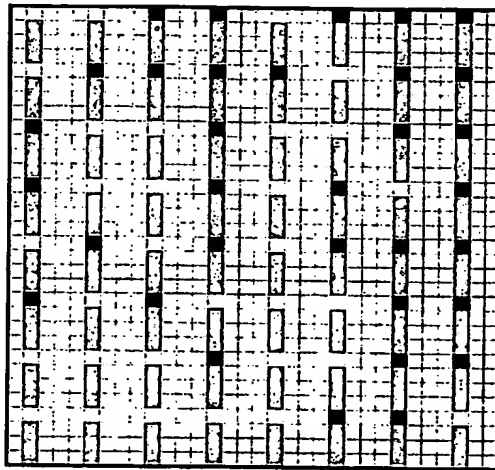


Figure 4. Geometry Optimized for 2 Stop Bands. Each Pixel is 1x1 Microns and the Unit Cell is 32x32 Microns.

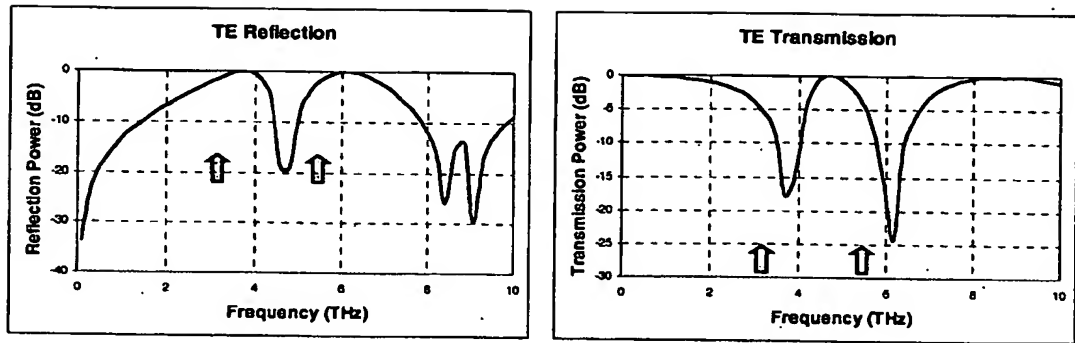


Figure 5. Transmission and Reflection Spectrums for Geometry in Figure 4.

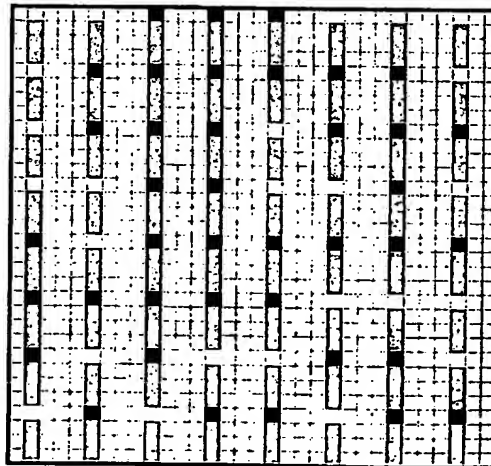


Figure 6. Geometry Optimized for 3 Stop Bands. Each Pixel is 1x1 Microns and the Unit Cell is 32x32 Microns.

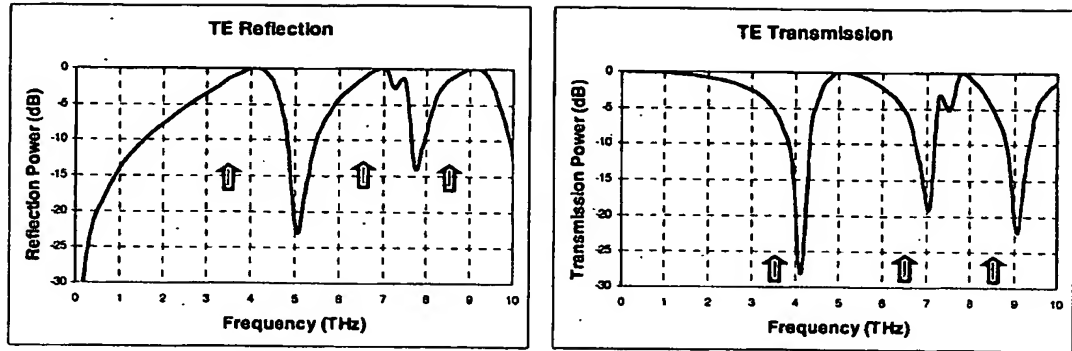


Figure 7. Transmission and Reflection Spectrums for Geometry in Figure 6.

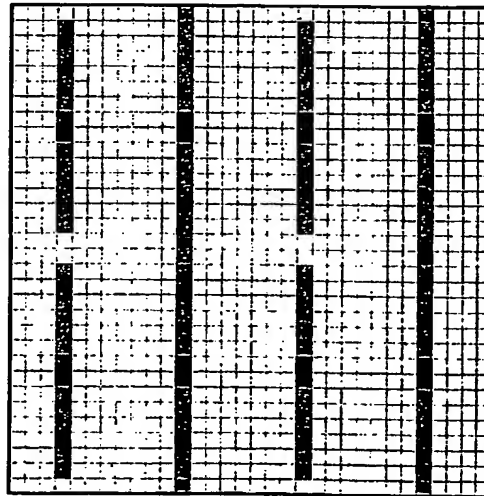


Figure 8. Reconfigurable FSS Geometry Demonstrating Two Independently Activated Sets of Switches. Each Pixel is 1x1 Microns and the Unit Cell is 32x32 Microns.

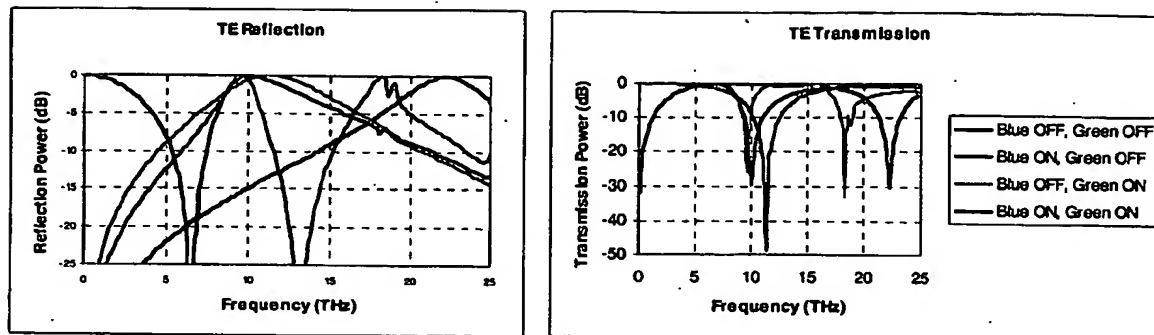


Figure 9. Transmission and Reflection Spectrums for all Four Possible Switch Settings Corresponding to the Geometry Shown in Figure 8.

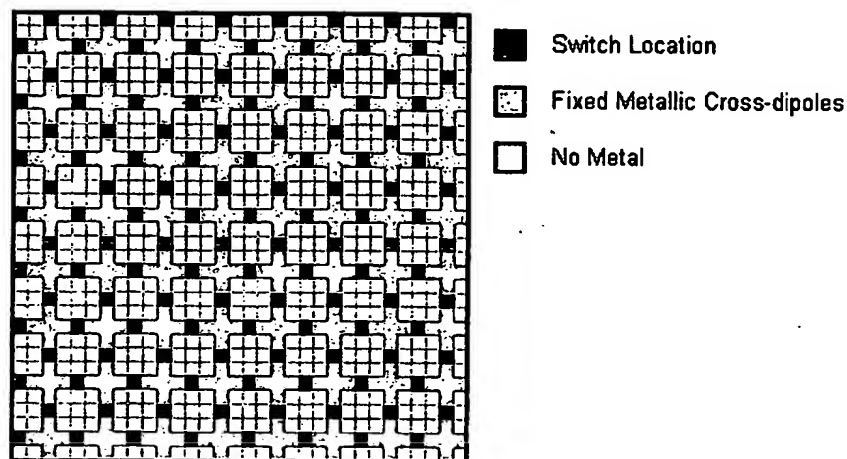


Figure 10. Reconfigurable FSS Geometry for Both TE and TM Polarizations. Possible Switch Locations are Shown in Blue. Each Pixel is 1x1 Microns and the Unit Cell is 32x32 Microns.

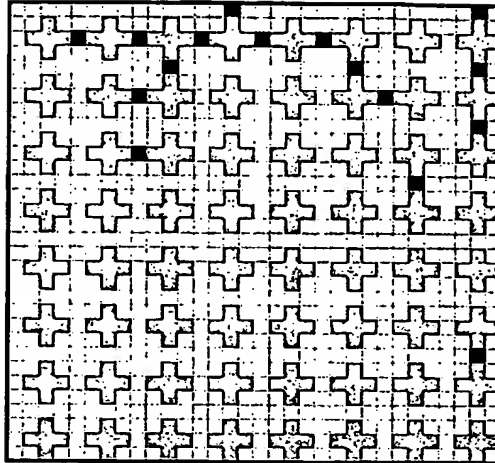


Figure 11. RFSS Geometry Optimized to Produce Two Stop-bands, One at 8 THz and One at 4 THz for a TE and a TM Polarized Wave Respectively.

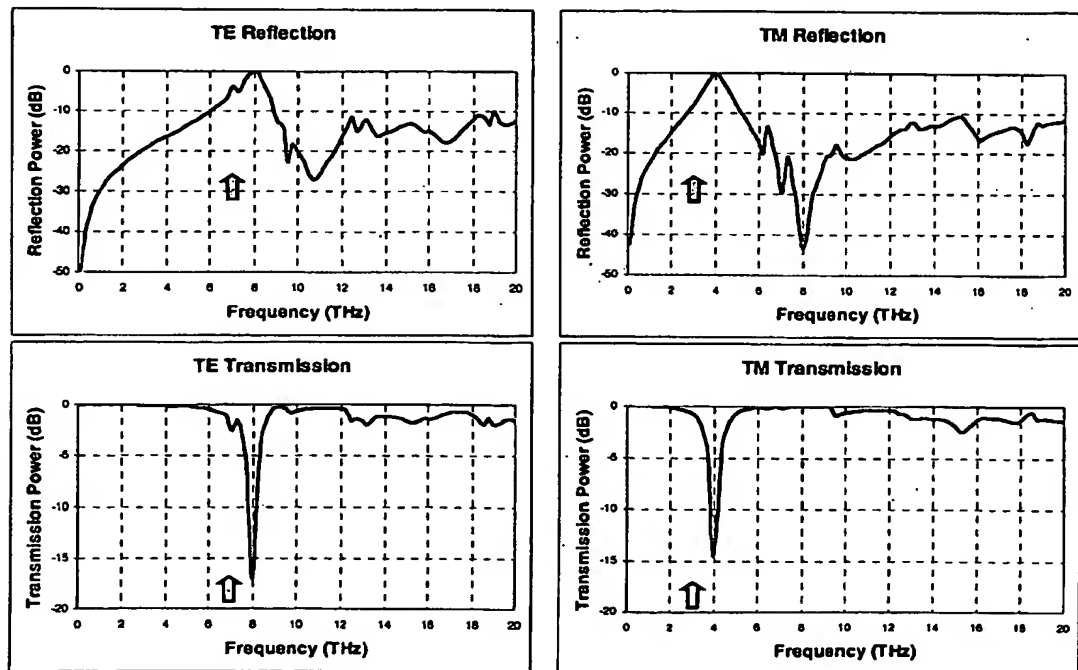


Figure 12. Transmission and Reflection Spectrums for RFSS Geometry Shown in Figure 11.

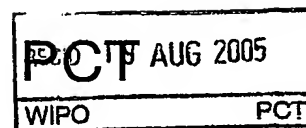
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Priority date (day/month/year)
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International Patent Classification (IPC) or both national classification and IPC
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- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA"). However, this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1b/s(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of three months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA:



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NL-2280 HV Rijswijk - Pays Bas
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Authorized Officer

Van Dooren, G

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**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US2005/001295

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
 - ☐ This opinion has been established on the basis of a translation from the original language into the following language , which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material:
 - ☐ in written format
 - ☐ in computer readable form
 - c. time of filing/furnishing:
 - ☐ contained in the international application as filed.
 - ☐ filed together with the international application in computer readable form.
 - ☐ furnished subsequently to this Authority for the purposes of search.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US2005/001295

Box No. III Non-establishment of opinion with regard to novelty, inventive step and Industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been examined in respect of:

- ☐ the entire international application,
- ☒ claims Nos. 43,44

because:

- ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):
- ☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 43,44 are so unclear that no meaningful opinion could be formed (*specify*):

see separate sheet

- ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
- ☐ no international search report has been established for the whole application or for said claims Nos.
- ☐ the nucleotide and/or amino acid sequence listing does not comply with the standard provided for in Annex C of the Administrative Instructions in that:
 - the written form ☐ has not been furnished
 - ☐ does not comply with the standard
 - the computer readable form ☐ has not been furnished
 - ☐ does not comply with the standard
- ☐ the tables related to the nucleotide and/or amino acid sequence listing, if in computer readable form only, do not comply with the technical requirements provided for in Annex C-*bis* of the Administrative Instructions.
- ☐ See separate sheet for further details

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US2005/001295

Box No. V Reasoned statement under Rule 43bis.1(a)(I) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	2,3,5,7-24,27-35,37-42
	No: Claims	1,4,6,25,26,36
Inventive step (IS)	Yes: Claims	3,5,12,22-24,37-42
	No: Claims	1,2,4,6-11,13-21,25,26,36
Industrial applicability (IA)	Yes: Claims	1-42
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. Claims 43,44 contain references to the description and/or the drawings. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:
D1 : US 2003/034933 A1 (FRENKEL AVRAHAM) 20 February 2003 (2003-02-20)
D2 : DAWEI ZHANG ET AL: "OPTICAL CONTROL OF MILLIMETER WAVE HIGH TC SUPERCONDUCTING QUASI-OPTICAL BANDPASS FILTERS" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 58, no. 14, 8 April 1991 (1991-04-08), pages 1560-1562, XP000209763
ISSN: 0003-6951
D3 : US 2002/167457 A1 (MCKINZIE WILLIAM E ET AL) 14 November 2002 (2002-11-14)
D4: L. DAI ET AL: "sensor and sensor arrays based on conjugated polymers and carbon nanotubes" PURE APPL. CHEM., vol. 74, no. 9, 2002, pages 1753-1772, XP002340646
2. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.
- 2.1 Document D1 discloses (the references in parentheses applying to this document): a frequency selective surface (10) comprising a periodically replicated unit cell (16), the unit cell including a chemoresistive material having an electrical conductivity that changes in a presence of an analyte (cf. §16).
3. The present application does not meet the criteria of Article 33(1) PCT, because the

subject-matter of claim 13-16 is not inventive in the sense of Article 33(3) PCT.

- 3.1 The use of an FSS as specified in claims 13-16 is considered to be ordinary practice, well-known to the person skilled in the art.
- 4. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 17 is not inventive in the sense of Article 33(3) PCT.
- 4.1 Document D2 discloses (cf. fig. 3): a process for detecting an analyte, the process comprising:
 - a) providing an apparatus including a resistive material, the resistive material having an electrical conductivity that changes on exposure to the analyte;
 - b) determining an electromagnetic property of the apparatus, the electromagnetic property being correlated with the electrical conductivity of the chemoresistive material; and
 - c) detecting the analyte using the electromagnetic property.

The subject-matter of claim 17 therefore differs from this known process in that the resistive material is a chemoresistive material.

The solution proposed in claim 17 of the present application cannot be considered as involving an inventive step (Article 33(3) PCT), because the use of chemoresistive materials is well-known, see for example D4.

- 5. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 25 is not new in the sense of Article 33(2) PCT.
- 5.1 As claim 25 is identical to claim 1, also claim 25 is not novel, cf. point 2 and 2.1.
- 6. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 32 is not inventive in the sense of Article 33(3) PCT.
- 6.1 The argumentation provided in point 4 and 4.1 applies to claim 32 *mutatis mutandis*.

7. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 36 is not new in the sense of Article 33(2) PCT.
- 7.1 Document D3 discloses (the references in parentheses applying to this document): an apparatus including a frequency selective surface FSS (400), the FSS comprising a pattern of conductive patches (410), the conducting patches being selectively interconnectable by a matrix of independently addressable switches (412).
8. Dependent claims 2, 4, 6-11, 17-21, 26 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty (claims 4,6,26) and/or inventive step (claims 2,7-11,17-21) (Article 33(2) and (3) PCT).
9. The technical features present in claims 3, 5, 12, 22 (23), 24, 37 (38-40), 41, 42 appear to satisfy the requirements of the PCT for what concerns novelty and inventive step.

Re Item VIII

Certain observations on the international application

1. Although claims 1,25,32,36 have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each other only with regard to the definition of the subject-matter for which protection is. The aforementioned claims therefore lack conciseness and as such do not meet the requirements of Article 6 PCT.
2. Throughout the set of claims the formulation '*chemoresistive material*' is not clear, as this is considered not to belong to the customary vocabulary of the person skilled in the art.
3. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1-D4 is not mentioned in the description, nor are these documents identified therein.

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING
AUTHORITY (SEPARATE SHEET)**

International application No.

PCT/US2005/001295

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From the INTERNATIONAL BUREAU

PCTNOTIFICATION CONCERNING
SUBMISSION OR TRANSMITTAL
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

Date of mailing (day/month/year) 27 September 2005 (27.09.2005)		To: BANCROFT, Martin, S. Gifford, Krass, Groh, Sprinkle, Anderson & Citkows ki, PC P.O. Box 7021 Troy, MI 48007-7021 ETATS-UNIS D'AMERIQUE
Applicant's or agent's file reference PST-16952/36		
International application No. PCT/US2005/001295	International filing date (day/month/year) 14 January 2005 (14.01.2005)	
International publication date (day/month/year)	Priority date (day/month/year) 14 January 2004 (14.01.2004)	
Applicant THE PENN STATE RESEARCH FOUNDATION et al		

1. By means of this Form, which replaces any previously issued notification concerning submission or transmittal of priority documents, the applicant is hereby notified of the date of receipt by the International Bureau of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to a date of receipt, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
2. (If applicable) The letters "NR" appearing in the right-hand column denote a priority document which, on the date of mailing of this Form, had not yet been received by the International Bureau under Rule 17.1(a) or (b). Where, under Rule 17.1(a), the priority document must be submitted by the applicant to the receiving Office or the International Bureau, but the applicant fails to submit the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
3. (If applicable) An asterisk (*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b) (the priority document was received after the time limit prescribed in Rule 17.1(a) or the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b)). Even though the priority document was not furnished in compliance with Rule 17.1(a) or (b), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

<u>Priority date</u>	<u>Priority application No.</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
14 January 2004 (14.01.2004)	60/536,444	US	22 July 2005 (22.07.2005)

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Sébastien CLAVERI Facsimile No. +41 22 338 7090 Telephone No. +41 22 338 8271
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Form PCT/IB/304 (January 2004)

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